

Done by Marianna

Which modality do you think would be the first to support a functional quantum computer?

Respond to questions 1 and 2

1. Why do you think your chosen modality will be the first one in supporting a functional quantum computer? Compare at least three modalities.
2. Think about the second modality that might be also a good candidate and answer the same as above.

The first modality that we think would be the first in this sphere to support a functional quantum computer is the usage of doped silicons. This is the compound of RF, microwave pulses and baseband. The main advantage of doped silicon is that it supports silicon fabrication technologies and the coherence time of the electron spin qubit is very long. Moreover, these phosphorus have nuclear spin which can be used as a qubit which is controlled by using RF pulses or radio frequency. Because of spin which is largely disengaged with their environment to take the coherence time very long. This is yet another advantage of the nuclear spin cubits. Although, the gate times are slower.

The second modality is the usage of trapped ions. This modality will correspond to the modern computing industry. This practice is still a significant challenge for the industry professionals. Making a quantum computer with trapped ions is necessary to integrate some technologies which include vacuum, optical systems, laser, radio frequency, coherent electronic controllers and microwave technology. Moreover, a data plane with trapped ions consists of ions that work as qubits and a trap which holds those ions in the particular place. The measurement and control plane have an accurate laser source that can be pointed at an exact ion and influence the latter's quantum state. Also, there is another laser which is used to measure the ions. Besides the lasers a set of photon detectors are used for measuring the condition of ions.

Third modality is superconducting qubits that look like microscopic things however they act as atoms. You can combine them with cavities as they have discrete energy levels. In the case of atoms we have cavity quantum electrodynamics which describes how easy atoms interact with cavities Although in case of superconducting qubits we have circuit QED and this describes how easier it is for a superconducting cubits to interact with cavities. The next advantage is that superconducting qubits are all silicon technologies and these qubits are produced on silicon wafers by using metal deposition, tools–photolithography, metal etch. As superconducting qubits are silicon technology they provide us with lithographic scalability.

On the other hand, we think that the best candidate after doped superconductors is the use of NV centers. These have long coherence time and are applicable to the communication of the quantum information and the inter conversion. These centers can work even at room temperature, although there will be low coherence. Nowadays, it is impossible to have the high

coherence nitrogen vacancies in accurate positions for creating large qubit arrays. That's why the main challenge for the NV centers is their capacity to be changed in scale. Compared with the second and third modalities discussed previously we think this modality will also be a good candidate to support a functional quantum computer.

Done by Satenik

2. When do you think the first functional quantum computer will be created?

Respond to questions 3 and 4

3. Why do you think it will take the time that you chose to create the first functional quantum computer? Argue at least two reasons.

4. Think about the time frame of the second modality that might also be a good candidate. Argue at least two reasons.

We think that it will take a minimum 10 years to achieve creating a functional quantum computer. Firstly, it is known that Intel succeeded in making a quantum simulator that uses about 5 trillion transistors in order to simulate 42 qubits. But for making a functioning quantum computer a commercially relevant product it needs more than million of qubits. The simplest way of making a quantum computer with so many qubits is by implying doped silicons. As discussed above doped silicons have nuclear spin which can be used as a qubit which is controlled by using RF pulses or radio frequency. The only issue with doing this is the amount of physical space it will take, so we don't have the best solution nowadays.

Additionally, if we dive into the history of computer architecture we see a pattern. In 1947 the first transistor was created and it took more than 10 years to make an integrated circuit(1958). Moreover, only in 1971 Intel succeeded in developing the first microprocessor using about 2.5 thousand of transistors. As we see, it took more than 10 years for all these integrated achievements to be realized, hence we believe it will take the same amount for developing a functional quantum computer.

For second modality: The other path is to shrink the inner dimensions of the integrated circuit, but that approach is unlikely with a superconducting system, which tends to be large. The spin qubits are a million times smaller, which is one of the reasons we're studying them as another option.

As mentioned before after doped superconductors, the use of NV centers is the best candidate for making a quantum computer. Also, we believe that it will take much more than 10 years, approximately 15, cause there will still be issues with creating large amounts of qubits. Also, the main challenge for the NV centers is their capacity to be changed in scale, that's why this modality will support the production of a quantum computer faster than all the other ones.